

# Orbiting Rainbows: Optical Manipulation of Aerosols and the Beginnings of Future Space Construction

Completed Technology Project (2012 - 2013)



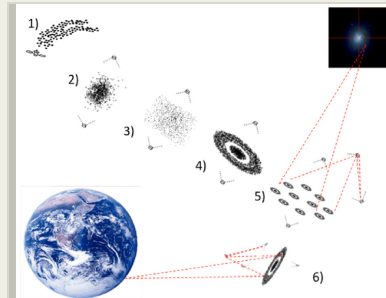
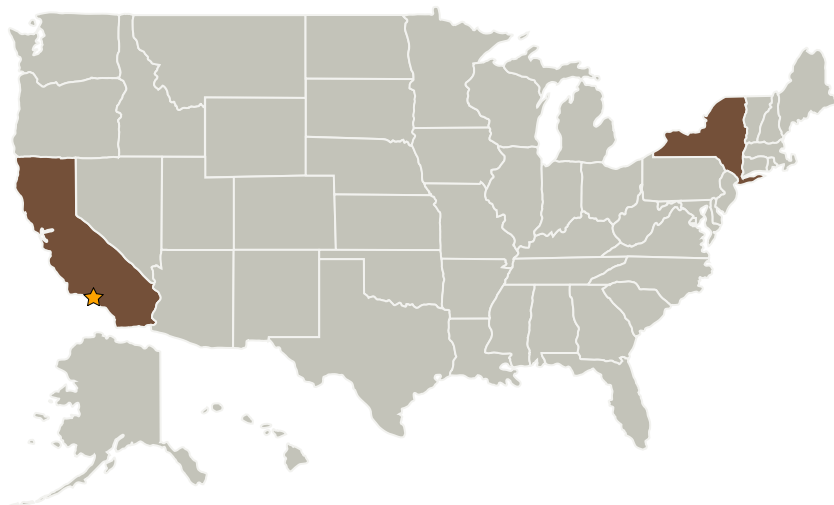
## Project Introduction

Our objective is to investigate the conditions to manipulate and maintain the shape of an orbiting cloud of dust-like matter so that it can function as an ultra-lightweight surface with useful and adaptable electromagnetic characteristics, for instance, in the optical, RF, or microwave bands.

## Anticipated Benefits

Our objective is to investigate the conditions to manipulate and maintain the shape of an orbiting cloud of dust-like matter so that it can function as an ultra-lightweight surface with useful and adaptable electromagnetic characteristics, for instance, in the optical, RF, or microwave bands. Inspired by the light scattering and focusing properties of distributed optical assemblies in Nature, such as rainbows and aerosols, and by recent laboratory successes in optical trapping and manipulation, we propose a unique combination of space optics and autonomous robotic system technology, to enable a new vision of space system architecture with applications to ultra-lightweight space optics and, ultimately, in-situ space system fabrication.

## Primary U.S. Work Locations and Key Partners



Project Image Orbiting Rainbows: Optical Manipulation of Aerosols and the Beginnings of Future Space Construction

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Organizations Performing Work	Role	Type	Location
★ Jet Propulsion Laboratory(JPL)	Lead Organization	NASA Center	Pasadena, California
California Institute of Technology(CalTech)	Supporting Organization	Academia	Pasadena, California
Rochester Institute of Technology(RIT)	Supporting Organization	Academia	Rochester, New York

## Primary U.S. Work Locations

California	New York
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## Project Transitions

 **September 2012:** Project Start

## Organizational Responsibility

### Responsible Mission Directorate:

Space Technology Mission Directorate (STMD)

### Lead Center / Facility:

Jet Propulsion Laboratory (JPL)

### Responsible Program:

NASA Innovative Advanced Concepts

## Project Management

### Program Director:

Jason E Derleth

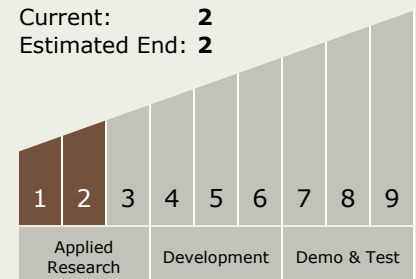
### Program Manager:

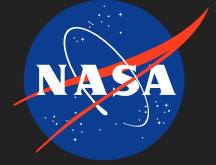
Eric A Eberly

### Principal Investigator:

Bruno M Quadrelli

## Technology Maturity (TRL)

Start: **1**Current: **2**Estimated End: **2**



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**June 2013:** Closed out

**Closeout Summary:** The work in Phase 1 was distributed among the following tasks: •Task 1: Kick-off activity •Task 2: Optical manipulation requirement definition •Task 3: Imaging system requirement definition •Task 4: Integrated mission scenario requirement definition •Task 5: Prepare and coordinate report and close-out activity To accomplish these tasks, we had identified the following milestones: •M1, at Start of Study: Kick off meeting for initial coordination between team members, and subcontract initiation. •M2, at end of Task 2: Cloud manipulation requirements developed •M3, at end of Task 3: Imaging system requirements developed •M4, at end of Task 4: Autonomy requirements developed •M5, at Study Completion: Final report completed Our initial plan was to address the overall mission design, find one or more candidate system architectures for the aerosol imaging system (for example: optical imager, hyper-spectral remote sensing), and identify technology gaps by addressing one or more of the following areas: a) Identification of practical methodologies to deploy and maintain an active cloud in space, b) Determination of requirements for extrapolation of optical lift technology to manipulation of macroscopic cloud, c) Determination of conditions required by aperture to function as either a transmitter, receiver, or lens, as a single or multiple aperture, d) Determination of key material/thermal properties of cloud, e) Determination of key miniaturization requirements to enable a minimum of autonomy (power, GNC, data transfer) at the grain level, f) Assessment of risk areas and mitigation plans for areas such as excessive scattering, loss of phase coherence, and orbital debris generation. g) Summary of findings and layout of plan forward to Phase II. Of this ambitious list, we have successfully addressed a), b), c), f), g). Points d), e), and partially f) (orbital debris mitigation) were left for Phase II, as we realized that they depended on a specific system architecture, yet to be developed at the time of the Phase 1 report. Furthermore, Milestone M2 (Cloud manipulation requirements developed) has been met, and is discussed in the section on Novel Techniques for Deployment, Cooling, and Reforming the Cloud of this report, Milestone M3 (Imaging system requirements developed) has been met, and is discussed in the section Exploring New Optical System Options of this report, and Milestone M4 (Autonomy requirements developed) has been met, and is discussed in the section on Cloud Engineering of this report. In summary, we have conducted a preliminary assessment of the initial feasibility of the concept, will have identified credible system architectures, and determined the crucial design parameters.

## Technology Areas

### Primary:

- TX05 Communications, Navigation, and Orbital Debris Tracking and Characterization Systems
  - └ TX05.2 Radio Frequency
    - └ TX05.2.3 Atmospheric Characterization and Mitigation

## Target Destination

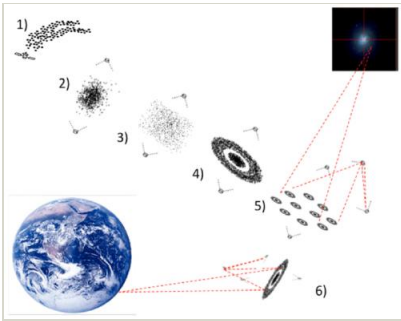
The Sun

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## Images



**11561-1366058219000.jpg**

Project Image Orbiting Rainbows:  
Optical Manipulation of Aerosols  
and the Beginnings of Future Space  
Construction  
(<https://techport.nasa.gov/image/102330>)